EEG Processing for Fast and Efficient Analysis

Kaspa Sudheer Kumar

Department of Electronics and Communication Engineering
National Institute of Technology Rourkela
Rourkela-769 008, Odisha, India

Thesis submitted in

May 2015

to the department of

Electronics and Communication Engineering

of

National Institute of Technology Rourkela

in partial fulfillment of the requirements

for the degree of

B.Techin

Electronics and Communication Engineering

by

Kaspa Sudheer Kumar

[Roll: 111EC0214]

Under the guidance of

Prof.D.P.Acharya, ECE Dept. NIT

Rourkela

Department of Electronics and Communication Engineering

National Institute of Technology Rourkela ,Rourkela-769 008, Odisha, India

Department of Electronics and Communication Engineering
National Institute of Technology Rourkela
Rourkela-769 008, Odisha, India

May 07, 2015

Certificate

This is to endorse that the work in the thesis entitled "**EEG processing for fast and efficient analysis"** by **Kaspa Sudheer Kumar** is a documentation of an authentic research work executed under my supervision and counsel in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering. Neither this thesis nor any part of this thesis work has been proposed for any degree or academic award elsewhere.

Prof.D.P.Acharya
Department of Electronics and Communication Engineering
NIT Rourkela

Acknowledgment

We express our heartfelt and sincere regards towards our guide Prof.D.P.Acharya sir for his able and accomplished guidance and motivation throughout the course of the project which served as an incentive to keep our work within time.

We would also like to thank our fellow friends and juniors who helped us in time of need and played a role for successful completion of our thesis work. Finally, we would be fully indebted to our parents for helping us survive all the stress for the past year and not letting me give up.

Kaspa Sudheer Kumar

Abstract

Hobbies on the human body have never diminished and explore on it has never ceased since hundreds of years back. An investigation of EEG for examination of the creation of the cerebrum and intellectual methods for biomedical applications is progressing theme for exploration. For the legitimate conclusion of numerous neurological maladies, for example, epilepsy, tumors, issues connected with injury exact examination of EEG signs is key. Moreover, to upgrade the viability of Brain Computer Interface (BCI) frameworks it is obliged to focus systems for expanding the sign to-commotion proportion (SNR) of the watched EEG signals. EEG measured by setting cathodes on scalp generally has little abundancy in microvolts, so the examination of EEG information and the extraction of data from this information is a troublesome issue. This issue gets to be more entangled by the presentation of antiques, for example, line commotion from the force lattice, eye flickers, eye developments, pulse, breathing, and other muscle action. Discrete wavelet change offers a viable answer for denoisingnonstationary EEG signals. In this paper, wavelet denoising is connected to EEG obtained amid performing diverse mental assignments. The initial decay of the EEG signal from database utilizing five unique sorts of wavelets viz. Haar, Daubechies, Symlet, Coiflet,Dmey is completed. In denoising process, the thresholding system utilized for expelling clamor from sullied EEG. Our goal to discover best suitable wavelet sort to specific errand which gave better execution measure, for example, bigger sign to-Noise Ratio (SNR). The EEG database from the Colorado state college is utilized for experimentation.

Keywords: *Denoising,Decomposing,Wavelets*

Contents

Chapter 1

Introduction

1.Introduction

An EEG sign is an estimation of streams that stream amid synaptic excitations of the dendrites of numerous pyramidal neurons in the cerebral cortex. At the point when mind cells (neurons) are enacted, the synaptic streams are created inside the dendrites. This current produces aattractive field quantifiable by electromyogram (EMG) machines and an optional electrical field over the scalp quantifiable by EEG frameworks. Contrasts of electrical possibilities are brought on by summed postsynaptic evaluated possibilities from pyramidal cells that make electrical dipoles between the soma (collection of a neuron) and apical dendrites, which branch from neurons .The present in the mind is produced for the most part by pumping the positive particles of sodium, Na^+, potassium, K^+,calcium, Ca^{++}, and the negative particle of chlorine, Cl^-, through the neuron layers in the course represented by the layer potential . The human head comprises of distinctive layers including the scalp, skull, cerebrum ,furthermore, numerous other slight layers in the middle. The skull constricts the signs give or take one hundred times more than the delicate tissue. Then again, a large portion of the commotion is created either inside the cerebrum (inner commotion) or over the scalp (framework clamor or outside commotion).Thusly, just huge populaces of dynamic neurons can produce enough potential to be recordable utilizing the scalp anodes.

Delta waves exist in the scope of 0.5–4 Hz. These waves are essentially related with profound slumber and may be display in the waking state. It is anything but difficult to befuddle antiquity signs brought about by the vast muscles of the neck and jaw with the veritable delta reaction.

This is on the grounds that the muscles are close to the surface of the skin and create substantial signs, though the sign that is of interest begins from profound inside the mind and is extremely constricted in going through the skull. By the by, by applying basic sign examination routines to the EEG, it is anything but difficult to see when the reaction is created by intemperate

.

2.Motivation

The neural movement of the human mind begins between the 17th and 23rd week of pre-birth advancement. It is accepted that from this early stage and all through life electrical signs created by the mind speak to the cerebrum work as well as the status of the entire body. This supposition gives the inspiration to apply progressed computerized sign transforming techniques to the electroencephalogram (EEG) signs measured from the cerebrum of a human subject.

3.Objective

The major objectives of this project are:

- To develop an efficient denoising technique
- To develop a novel time and frequency resolution analysis for EEG signal
- Efficient sub-band decomposition and reconstruction

4.Organization of the Thesis

The thesis is organized as follows.

In chapter 2, we have given the literature survey

In chapter 3, we have proposed our methodology fordenoising and decomposition of the given EEG signal.

In chapter 4, we give the implementation details and the results.

In chapter 5, we give the concluding remarks with a focus on future research directions that could be undertaken.

Chapter 2

Literature

1.Literature

Many techniques have been developed for the detection,removal and correction of artifacts in a signal.The proposed strategy was taking into account separating the entire information set into bordering windows, at that point measurable tests on every window were connected. On the off chance that the antique was recognized at any divert in any window, all information in this window is stamped for dismissal. Despite the fact that this system meets expectations ef□ciently in recognizing artifacts,rejection of the entire information inside the checked window has downsides in light of the fact that some helpful information in the uncontaminated channels inside this stamped window is lost.In the creators proposed utilizing ICA with a reference signal. This procedure is in light of removing sources that are factually free and are compelled to be comparative to the given reference signal. In spite of the fact that this system was connected effectively in dismissing visual antiques, it is not on–line, and the first flags must be analysed □rst keeping in mind the end goal to choose a suitable reference signal. These restrictions make this procedure unsatisfactory for constant programmed dismissal and rectification of visual curios. In PCA was connected to particular the EEG signals into uncorrelated segments. At that point for every differentiated segment, tests were connected keeping in mind the end goal to recognize whetherthis segment is an antiquity or not. On the off chance that the divided segment is stamped as antique, the entire part is situated equivalent to zero, then the remedied EEG signs are restoredy reproducing these amended sources by the opposite of the differentiating grid.

2.Features extracted from the signal:

In general we have normal EEG signal which is seen in Time domain only.The signal features may be taken away by noise.To get the features of given EEG signal we need to get the information regarding the energy in some time domain.The features extracted based on the frequency domain are called the most eeffective features to find the emotional occurrence.

The initial was to perform Fast Fourier Transform by apply DFT (Discrete Fourier Transform) to find the signal into its frequency domain. The data sequence is applied to data windowing, producing modified periodograms

Advantages of Frequency based features

(i) Good device for stationary sign handling

(ii) It is more proper for narrowband sign, for example, sine wave

(iii) It has an improved speed over for all intents and purposes all other accessible strategies continuously applications

Disadvantages are

(i) Weakness in dissecting nonstationary flags, for example, EEG

(ii) It doesn't have great spectral estimation and can't be utilized for investigation of short EEG signals

(iii) FFT can't uncover the restricted spikes and complexes that are availed among epileptic seizures in EEG signals

(iv) FFT experiences vast clamor affectability, and it doesn't have shorter length of time information record

Eigenvector Decomposition: We have Eigen vector decomposition features where signal is buried with noise.

Advantage of these features give suitable determination to assess the sinusoid from the information.

Disadvantage is theLowesteigen value can cause false valued zeros when Pisarenko’s technique is used.

Wavelet Transform Method:Mainly used for non stationary and transient signals.

(i) It has a differing window size, being wide at low frequencies and restricted at high frequencies

(ii) It is more qualified for examination of sudden and transient sign changes

(iii) Better ready to examine unpredictable information designs, that is, driving forces existing at diverse time cases

But the main challenge is to find proper wavelet which yields good results.

Auto Regressive method : this is signal feature extraction in Frequency domain that is used for signal containing sharp features in spectrum.

Advantages are:

(i) AR restricts the loss of spectral issues and yields enhanced frequency resolution

(ii) Gives great recurrence determination

(iii) Spectral examination in light of AR model is especially favorable when short information sections are examined, following the recurrence determination of a systematically determined AR range is boundless and does not rely on upon the length of broke down information

Disadvantages are:

(i) The model request in AR ghastly estimation is hard to choose

(ii) AR technique will give poor phantom estimation once the evaluated model is not suitable, and model's requests are inaccurately chosen

(iii) It is promptly defenseless to substantial inclinations and even vast variability

It is very recquired to make pass the of the sign to be investigated in the use of the system, at whatever point the execution of examining strategy is talked about. Considering this, the ideal strategy for any application may be diverse.

3.Classification methods

With a specific end goal to pick the most suitable classifier for a given arrangement of highlights, the properties of the accessible classifiers must be known. This area gives a classifier scientific categorization. It likewise manages two grouping issues particularly pertinent for BCI research, in particular, the condemnation of-dimensionality and the Bias-Variance tradeoff.

Linear classifier:

Direct classifiers are discriminant calculations that utilization straight capacities to recognize classes. They are presumably the most famous calculations for BCI applications. Two principlesorts of direct classifier have been utilized for BCI plan, to be specific, Linear Discriminant Investigation (LDA) and Support

This classifier presents a regularization parameter C that can permit or punish characterization lapses on the preparation set. The subsequent classifier can accomodate exceptions and get better speculation abilities. As anomalies are regular in EEG information, this regularized form of LDA may give preferable results for BCI over the non-regularized adaptation..

Support Vector Machine

A SVM likewise utilizes a distinct kind of plane to distinguish classes. Then again, particular SVM, the chose plane is the particular case that augments the edges, i.e., Amplifying the edges is known to build the speculation capabilities,an SVM utilizes a regularization parameter C that empowers accommodation to exceptions and permits blunders on the preparation set.

Such an SVM empowers arrangement utilizing straight choice limits and is known as straight SVM. This classifier has been connected, dependably with accomplishment, to a generally extensive The quantity of synchronous BCI issues. In any case, it is conceivable to make nonlinear choice limits, with just a low increment of the classifier's multifaceted nature, by utilizing the "portion trap". It comprises in certainly mapping the information to another space, for the most part of much higher dimensionality, utilizing a portion capacity K(x, y). The portion for the most part utilized as a part of BCI exploration is the Gaussian or Radial Basis Function (RBF) portion:

4.Compression Methods

4.2.2. EEG Data Compression

Lossy EEG information and lossless pressure strategies have been used in the writing. The most generally known techniques utilize reiteration tally, Huffman coding, vector quantization, and methods taking into account signal indicators, for example, Markov indicator, computerized sifting indicator, (versatile) straight indicator, greatest probability, simulated neural systems .By and by, word reference based methods (LZ77, LZ78) try not to function admirably when connected to the EEG information, since their proficiency is in light of the abuse of the continuous reoccurrence of

certain precise examples distinguished in the information, a rule that does not matter in the nondeterministic way of the EEG signal. Utilizing the EEG learning, pressure can be upgraded by evacuating repetition, regarding factual reliance between tests. Time reliance, abused by the forecast systems, can prompt the estimation of the following example from the past ones by including some deferral inputs to the indicator, while spatial reliance between info EEG channels can be caught by lossless strategies in view of multivariate time arrangement examination (Cohen et al., 1995), and vector quantization .In the last, the information EEG channels (or subsidiaries) tests are mapped to a code vector and encoding is performed just to the lapse vector.

techniques are used are highly dependent on the media that is being compressed. Lossy compression for sound, for example, is very different than lossy compression for images. In this section we go over some general techniques that can b be applied in various contexts, and in the next two sections we go over more specific examples and techniques.

Chapter 3

Analysis and Implementation

1.Pre processing and Filtering

To overcome the low SNR of individual trials, it is common practice to average together many consecutive trials, which effectively diminishes the random noise. Unfortunately, when more repeated trials are required for applications such as the P300 speller, the communication rate is greatly reduced. Since the noise results from background brain activity and is inherent to the EEG recording methods, signal analysis techniques like blind source separation (BSS) have the potential to isolate the true source signal from the noise when using multi-channel recordings. This thesis provides a comparison of three BSS algorithms: independent component analysis (ICA), maximum noise fraction (MNF), and principal component analysis (PCA). In addition to this, the effects of adding temporal information to the original data, thereby creating time embedded data, will be analyzed. The BSS methods can utilize this time embedded data to find more complex spatio-temporal filters rather than the purely spatial filters found using the original data

Visually impaired Source Separation Blind source detachment (BSS) techniques are taking into account the presumption that the watched signs from a multi-channel recording are delivered from a mixture of a few unmistakable source signals. In the connection of EEG recordings, numerous spatially unmistakable cerebrum sources are accepted to add to the general watched EEG signal. ICA, PCA, and MNF have all indicated to be effective at evacuating curios in EEG [21, 22, 23] through BSS. Ancient rarities are thought to be any kind of EEG tainting coming about because of organically created or outside sources. A few samples are muscle movement, eye squints, or 60 Hz line clamor. Each of these BSS systems are known to confine the antique movement into individual source segments. Contrasted with P300 source extraction, relic extraction is a much simpler errand since the tainting signs are typically expansive in respect to the progressing EEG movement. At the point when utilized for P300 characterization, just ICA has been connected and indicated to confine the P300 signal into source parts.

Wavelet Transform and Denoising

Fourier progressions based spooky examination is the dominating analytic gadget for repeat space examination. Then again, Fourier change can't give any information of the reach changes concerning time. Fourier change expects the sign is stationary, yet PD sign is reliably non-stationary. To thrashing this insufficiency, a adjusted framework brief time Fourier change grants to identify with the sign in both times besides, repeat range through time windowing limit. The window length chooses a consistent time and repeat determination. Subsequently, a shorter time windowing is used as a piece of the appeal to catch the transient behavior of a sign; we give up the repeat determination. The method for the honest to goodness PD signs is nonperiodic and transient as exhibited; such banners can't without quite a bit of a stretch be inspected by routine changes. Hence, an elective numerical instrument wavelet change must be decided to focus the apropos time-sufficiency information from a sign. In the mean time, we can improve the sign to bustle extent in perspective of prior data of the sign qualities.

In this work, we communicated simply a couple of keys numerical proclamations and thoughts of wavelet change, more intensive investigative treatment of this subject can be found in [30-35]. A relentless time wavelet change of f(t) is described as:

Here a, b ∈R, a ≠ 0 and they are broadening and interpreting coefficients, independently. The pointer demonstrates a confusing conjugate. This increment of an is for imperativeness institutionalization purposes so that the changed sign will have the same essentialness at every scale. The examination limit) ψ (t , the charged mother wavelet, is scaled by a, so a wavelet examination is as often as possible called a period scale examination rather than a period repeat examination. The wavelet change separates the sign into unmistakable scales with various
levels of a determination by broadening a single model limit, the mother wavelet.
Furthermore, a mother wavelet needs to satisfy that it has a zero net zone, which suggest that the change piece of the wavelet change is an insignificantly reinforce limit (constrained in time), therefore offering the likelihood to catch the PD spikes which commonly happen in a brief time of time

4.2 Discrete Wavelet change and Multiresolution Analysis

One drawback of the CWT is that the representation of the sign is consistently abundance, since an and b are reliable over R (the certifiable number).
The gathering of broadened mother wavelets of picked an and b constitute an orthonormal reason
The differentiations between assorted mother wavelet limits (e.g. Haar, Daubechies, Coiflets, Symlet, Biorthogonal et cetera.) embody in how these scaling signs and the wavelets are portrayed. The choice of wavelet chooses the last waveform shape; additionally, for Fourier change, the broke down waveforms are reliably sinusoid. To have an amazing imitated sign from wavelet transform, we need to pick the orthogonal wavelets to perform the progressions.
The wavelet crumbling realizes levels of approximated and bare essential coefficients.
The count of wavelet sign deterioration is spoken to in Fig 22. Amusement of the sign from the wavelet change and post changing, the count is shown in
This multi-determination examination enables us to dismember the sign in assorted repeat bunches; thus, we could observe any transient in time space furthermore in repeat territory.

4.3 Wavelet-based Denoising

The general wavelet denosing strategy is according to the accompanying:

• Apply wavelet change to the uproarious sign to convey the rowdy wavelet coefficients to the level which we can genuinely perceive the PD occasion.
• Select fitting edge limit at each level and edge strategy (hard or sensitive thresholding) to best empty the noises.
• Inverse wavelet change of the thresholded wavelet coefficients to get a denoised sign.

4.3.1 Wavelet determination

"Mother wavelet" won't simply choose how well we assess the first banner with respect to the condition of the PD spikes, also, it will impact the repeat scope of the denoised sign. The choice of mother wavelet can be considering eyeball survey of the PD spikes, or it can be picked in light of association γ between the indication of interest and the wavelet-denoised sign, or considering the aggregate imperativeness over some break where PD spikes happen.
We choose to pick the mother wavelet in light of the last two frameworks: association between two signs and joined imperativeness over some interval of PD spike occasion.
We found that the two schedules issue us an in a general sense the same result.

4.3.2 Threshold limits

Various schedules for setting the edge have been proposed. The most drawn out way is to arranged quite far on a case-by-case premise. The most extreme is picked such that adequate tumult departure is refined. For a Gaussian bustle; if we apply orthogonal wavelet change to the uproar signal, the changed sign will defend the Gaussian way of the disturbance, which the histogram of the racket will be a symmetrical ringer formed curve about its mean worth. From theory, four times the standard deviation would cover 99.99% of the

2.Feature Extraction

FEATURE EXTRACTION

The reason for feature extraction is to lessen the first information by measuring certain features that recognize one info design from another. At the point when the data information to a calculation is

so extensive it couldn't be possible be transformed and it is suspected to be famously excess (much information, however very little data) then the info information will be changed into a decreased representation set of features (additionally named highlight vector). Changing the information into the arrangement of features is called highlight extraction. In the event that the highlights separated are deliberately picked it is normal that the features set will extricate the pertinent data from the info information with a specific end goal to perform the craved assignment utilizing this decreased representation rather than the full size info

.

Entropy:

Entropy is a numerical measure of the irregularity of a sign. Entropy can go about as A highlight and used to examine mental time arrangement information, for example, EEG information. The Entropy can subsequently be computed as:

$$e = -\sum_{1}^{n} x^2 - \log(x^2)$$

Support vector Machine:

Support Vector Machine (SVM) is generally utilized for information order. The Support vector machine (SVM) is a regulated learning technique that produces info yield mapping capacities from an arrangement of marked preparing information. The objective of SVM is to deliver a model (in light of the preparation information) which arranges the test information. An order undertaking for the most part includes dividing information into preparing and testing sets.SVM can characterize information divided by non-direct and straight limits. Through the piece capacities, the issue is certainly mapped to a higher dimensional space in which hyper planes suffice to characterize the limits. SVM is likewise equipped for ordering covering and non-distinguishable information. A punishment is alloted for data information that fall on the wrong side of the hyper planes, and an ideal position is found.

Support vector machines guide information vectors to a higher dimensional space where a maximal differentiating hyperplane is built. Two parallel hyperplanes are developed on every side of the hyperplane that expands the separation between the two parallel hyperplanes. A supposition is made

that the bigger the edge or separation between these parallel hyperplanes the better the speculation mistake of the classifier

In linear SVM classifier two label 3 and 4 is created for normal EEG signal and seizure EEG signal. The feature values are trained based on the label values.

Consider the problem of binary classification .The training data is given by the equation .

$(x1,y1),(x2,y2),\ldots..,(xi,yi)$, $x\varepsilon Rn$,$y\varepsilon\{ +1,-1\}$

EEG Compression:

In the present times the compression of EEG signal has become very important because of the need for speed transmission and efficient storage.It decreases transmission time,storage space recquired in portable sensing instruments.It helps in decreasing decreasing number of channels and bandwidth.The need for compression is of Horlets.Horlets are long term EEG signal which are to be recorded when symptoms occur very rarely.

This causes us to reduce the sampling rate by half and few recording channels. Even then the minimized signal quality.

Indeed, even with this decreased one, 66 Mb are obliged to save a Holter of 24 h; accordingly, pressure procedures are valuable and financially convenient.Lossless information pressure can be attained to by allotting short portrayals to the most regular images of an information source and fundamentally more depictions to the less incessant images. It may demonstrated that there is no loss of simplification for just prefix codes. Truth be told, given an ideal information pressure achievable with a variable length code, there exists a prefix code that accomplishes the same result .

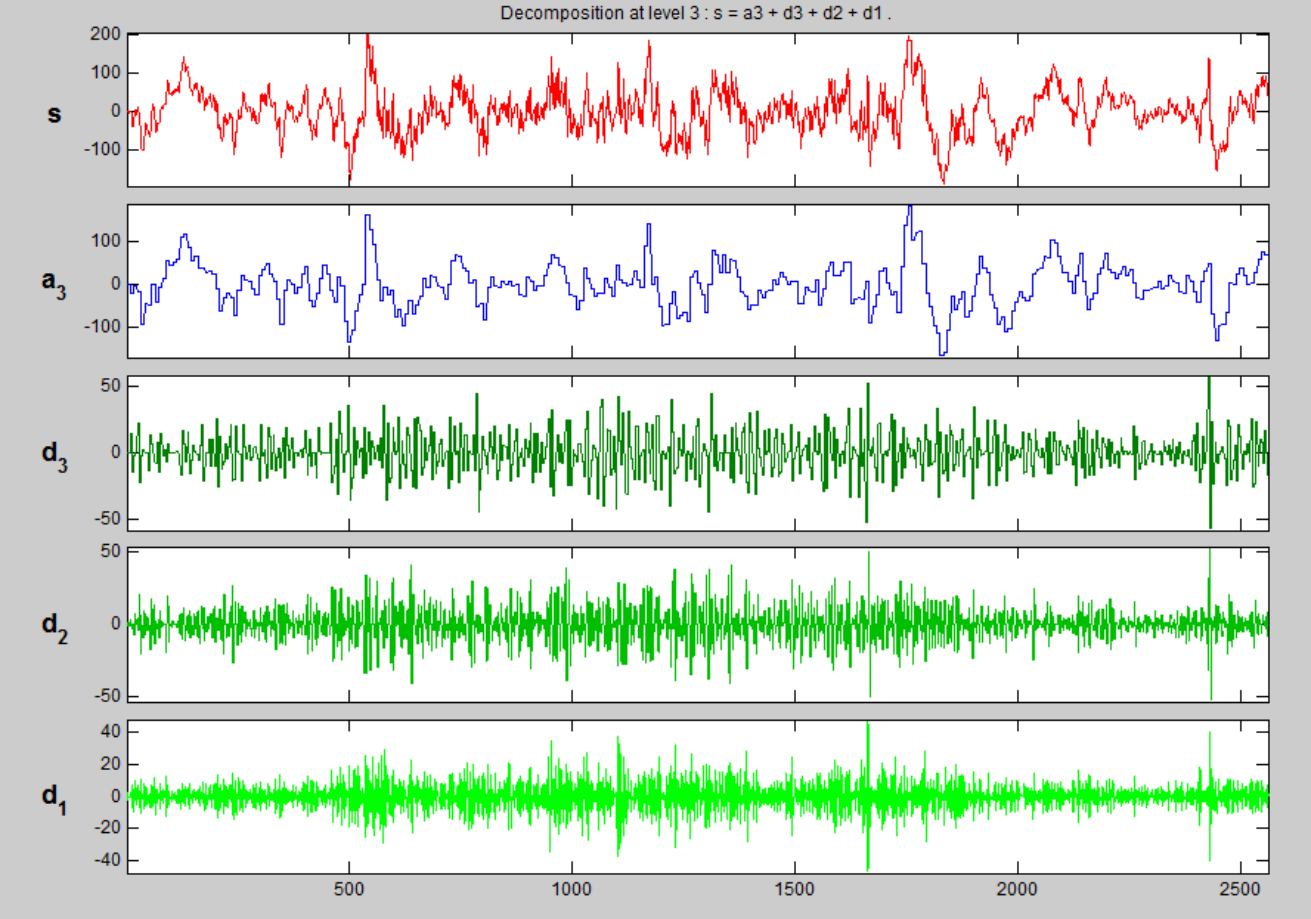
Actually, they allow one to perceive a codeword without earlier learning of its length, as a left-to-right output of its bits can never all the while fulfill one codeword and the prefix of anothercodeword.

Loseless Huffman coding

Wavelet based Sub band coding

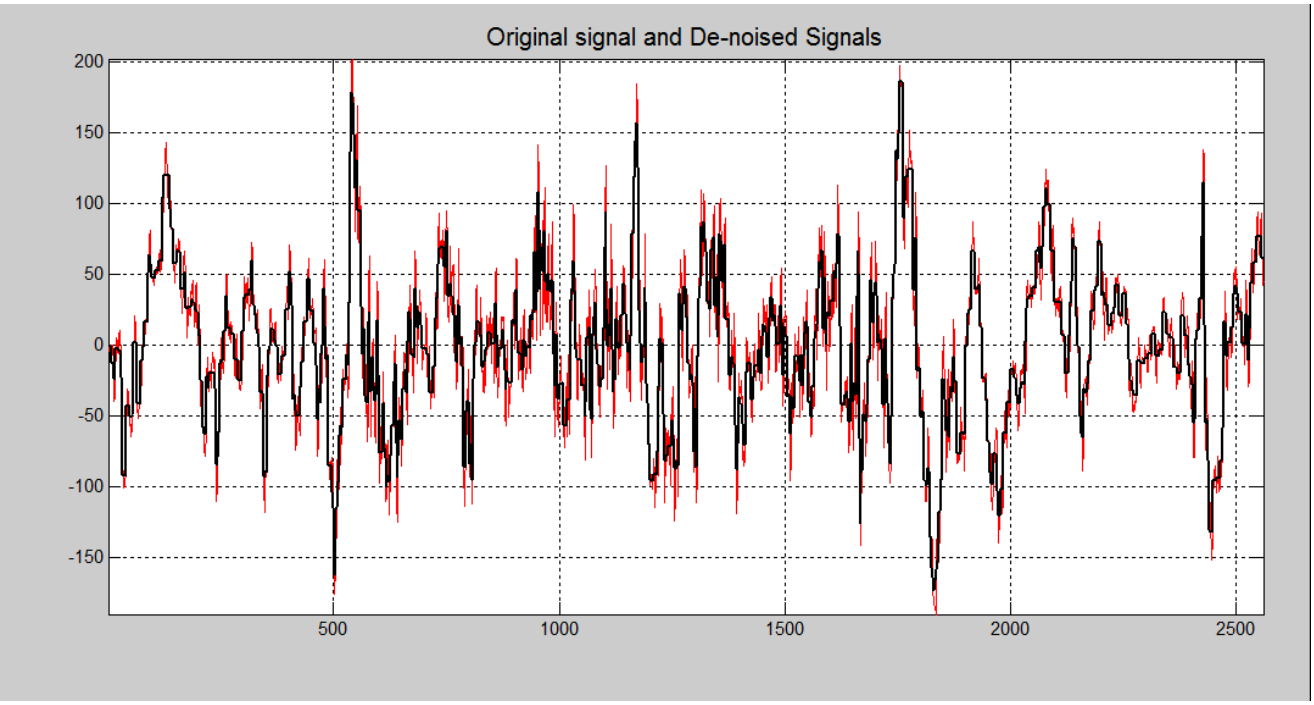
Chapter 4

Results



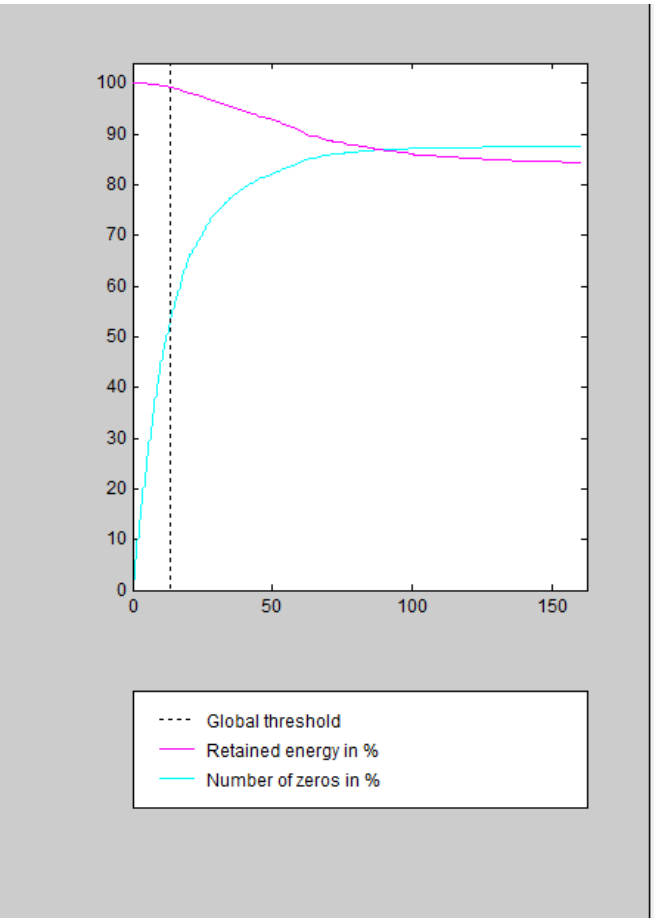
Result1

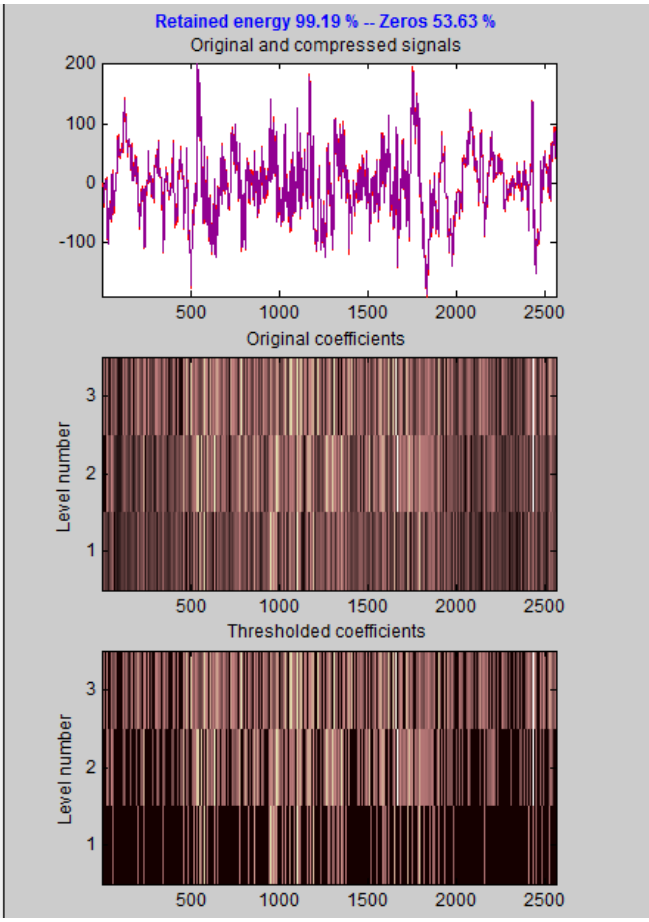
WAVELET DECOMPOSITION



Result2

Wavelet Based Denoising





Result3

EEG Wavelet based Compression

Chapter 6

Applications

1.Applications

1. Sleep Stage Detection:EEG helps in diagnosing the disorder related to sleep apnea.It helps in curing the sleep disorders by use of some drugs
2. Epileptic Seizures : A significant part world population suffers from Epileptic seizure .With the use EEG detection techniques it can help in checking the disorders and helps in curing by the use of drugs
3. Emotional Recognition:
4. Alertness of the drivers or doctors : The doctors performing kidney or heart related operations have to highly alert.The alertness of the doctors can be found out by certain waves which signify alertness.
5. An easy transfer and storage of EEG data for the Hortley based patients

Chapter 7

Conclusion and Future work

1.Conclusion

In present day environment the people with brain or brain wave disorders have become significantly high.So the need has come for better detection techniques and recording instruments.The devices which are being employed have to be capable of handling large amounts of data,storing them and processing.So using present time compression techniques we are able perform

2.Future Work

This innovation could be the eventual fate of what I call a "reflection economy." Deeply mindful people who have more noteworthy control over their psyches and consideration could manage machines, PCs and

innovation better than their diverted human companions. This is an energizing course for brain science, and reasoning and could aid mankind in turning into a more intelligent society. EEG innovation could likewise build our thankfulness for coordinated and true proposition.

Bibliography

[1] W.Methods of EEG Signal Features Extraction Using Linear Analysis in Frequency and Time-Frequency DomainsISRNNeuroscienceVolume 2014 (2014), Article ID 730218, 7 pageshttp://dx.doi.org/10.1155/2014/730218

[2] Giuliano Antoniol,* *Member, IEEE,* and Paolo Tonella "EEG Data Compression Techniques", *IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 44, NO. 2, FEBRUARY 1997.*

[3] Zhitao Lu, Dong Youn Kim and William A. PearlmanElectrical, "Wavelet Compression of ECG Signals by the SetPartitioning in Hierarchical Trees (SPIHT) Algorithm", *IEEE Transactions on Biomedical Engineering. Troy, NY 12180-3590,January 12, 2000.*

[4] JULIA´N L.CA´ RDENAS-BARRERA,JUAN V. LORENZO-GINORI* and ERNESTO RODRI´GUEZ-VALDIVIA, "A wavelet-packets based algorithm for EEG signal compression", *Med. Inform. (MARCH 2004) Vol. 29, NO. 1, 15 ‑27. .*

[5] J. Alon, V. Athitsos, Q. Yuan, S. Sclaroff, "A Simple and Fast Algorithm for Automatic Suppression of High-Amplitude Artifacts in EEG Data", *Acoustics, Speech and Signal Processing, 2007. ICASSP 2007. IEEE International Conference on, 2007.*

[6] Varun Bajaj, Ram Bilas Pachori,"EEG Signal Classification using Empirical Mode Decomposition and Support Vector Machine", *Proceedings of the International Conf. on SocProS 2011*, AISC 131, pp. 581-592,Springer India 2012, Oct. 2012.

[7] D. Boutana, M. Benidir, B. Barkat,"Segmentation and identi_cation of some pathological phonocardiogram signals using time-frequency analysis",IET Signal Processing, Volume:5 , Issue: 6, pp. 527 - 537, Sept. 2011.

[8] J. Alon, V. Athitsos, Q. Yuan, S. Sclaroff, "A Unified Framework for Gesture Recognition And Spatiotemporal Gesture Segmentation", *IEEE Transaction of Pattern Analysis andMachine Intelligence, 2008.*

[9] Chrysa D. Papadaniil, Leontios J. Hadjileontiadis,"Patient-speci_c epilepticseizure detection in long-term EEG recording in paediatric patients with intractable seizures*", IEEE Journal of Biomedical and Health Informatics*,Dec. 2013.

[10] Ahmad MIRZAEI, Ahmad AYATOLLAHI, Ali MotieASRABADI,"Automated detection of epileptic seizures using mixedmethodology:Wavelet-Chaos-KNNClassi_er-Mutual Information",2097, R. 87 NR 4/2011, Oct. 2010.

[11] M. Niknazar, S. R. Mousavi, B. VosoughiVahdat,M. Sayyah,"A New Framework Based on Recurrence Quanti_cation Analysis for Epileptic Seizure Detection", *IEEE Journal of Biomedical and Health Informatics*, VOL. 17, NO.3, MAY 2013, Mar. 2013.

[12] Yatindra Kumar, M.L Dewal, R.S Anand,"Wavelet Entropy Based EEGAnalysis for Seizure Detection", *IEEE Conference Publications*, Mar. 2013.